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AS210-02
FREQUENCY
COMPARATOR MODULE

OPERATION AND MAINTENANCE MANUAL

MP MASTER
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INSTRUMENTATION AND METROLOGY DIVISION

M84-0020

AS210-02
FREQUENCY
COMPARATOR MODULE

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PREFACE

This manual contains operation and maintenance instructions for the AS210-02 Frequency Comparator. The data contained herein is arranged as follows:

Chapter 1	General Information
Chapter 2	Installation
Chapter 3	Operation
Chapter 4	Theory of Operation
Chapter 5	Maintenance and Calibration
Chapter 6	Illustrated Parts List

Reference Publications

AS210RM	Rack Mount Mainframe Operation and Maintenance Manual
AS210PM	Portable Mainframe Operation and Maintenance Manual
AS210-01A	Module Controller Operation and Maintenance Manual
AS210-03	Frequency Generator Operation and Maintenance Manual
AS210-04	Digital Delay Generator Operation and Maintenance Manual
AS210-05	Standby Battery Operation and Maintenance Manual
AS210-06	Microwave Generator Operation and Maintenance Manual
AS210-08	Distribution Amplifier Operation and Maintenance Manual
AS210-20	Time Clock Operation and Maintenance Manual

CHAPTER 1
GENERAL INFORMATION

-1 INTRODUCTION

The AS210-02 Frequency Comparator illustrated in Figure 1.1 is a modular plug-in of the AS210 Electronic Counter and Frequency Standard Calibration system. The unit plugs into the AS210 Mainframe which provides power and control. Up to six different time bases can be connected to the AS210-02 front panel for measurement of frequency accuracy. The internal circuitry of the AS210-02 automatically adapts to any of the allowable standard input frequencies to be measured. Samples are taken at a maximum rate or once per hour and up to 500 samples can be stored for computation of warm-up characteristics, drift rate, and aging. This module can be programmed through the IEEE-488 interface in the AS210-01 Module Controller.

-2 PHYSICAL AND ELECTRICAL DESCRIPTION

The AS210-02 Frequency Comparator is a single width plug-in unit. Front panel controls select frequency resolution and sampling rate. Six BNC input connectors on the front panel permit connection of the time bases or frequency standards to be measured. The circuitry of the module is mounted on two printed circuit card assemblies. Basically, the Frequency Comparator converts the input to be measured to a 100 KHz test signal, then compares it to the 10 MHz Rubidium Frequency Standard in the AS210 Mainframe. The difference between the standard and measured signal is accumulated in registers and reviewed periodically by the microprocessor in the Module Controller which then performs calculations of drift rate. Table 1-1 is an equipment specification for the AS210-02 Frequency Comparator as installed in the AS210 Mainframe with the AS210-01 Module Controller. The Module Controller and Mainframe are covered in separate publications listed in the preface.

Figure 1.1 AS210-02 Frequency Comparator

Table 1-1

AS210-02 EQUIPMENT SPECIFICATION

NPUTS	Six
NPUT VOLTAGE RANGE	0.5V to 10V RMS
NPUT IMPEDANCE	1000 ohms nominal
NPUT FREQUENCY	0.1, 1, 5, or 10 MHz
ESOLUTION	10^{-8}, 10^{-9}, 10^{-10}, or 10^{-11} selectable
AMPLE TIME	0.5 seconds for 10^{-8} resolution
	5.0 seconds for 10^{-9} resolution
	50 seconds for 10^{-10} resolution
	500 seconds for 10^{-11} resolution
AMPLE RATE	
MAX MODE	Approximately 0.5 seconds between readings
1-PER-HOUR MODE	Each input sampled once per hour
ESOLUTION ACCURACY	
10^{-8} RANGE	$\pm$1 part in 10^{-8}
10^{-9} RANGE	$\pm$1 part in 10^{-9}
10^{-10} RANGE	$\pm$1 part in 10^{-10}
10^{-11} RANGE	$\pm$1 part in 10^{-11}
PERATING TEMPERATURE	0° to 40°C
WER	Supplied by AS210 Mainframe
IGHT	2.0 lbs

CHAPTER 2
INSTALLATION

2-1 INTRODUCTION

The AS210-02 Frequency Comparator plugs into the AS210 Mainframe. The module is electrically connected through the rear connector and mechanically retained via a front panel locking bar on the Mainframe. A release mechanism is located in the lower left hand corner of the front panel. Power and signal interface is provided through the Mainframe. The signals to be measured are connected to the BNC connectors located on the front panel.

NOTE 1: The Frequency Comparator Module is held in the card edge connector with high retention force. In order to remove the module, it may be necessary to pull on the front panel RANGE switch while the release mechanism is pulled.

NOTE 2: Ensure that power is turned OFF in the AS210 Mainframe before installing or removing the AS210-02.

CAUTION

Do not attempt to use the AS210 series modules in a Tektronix Mainframe as severe damage will result.

CHAPTER 3
OPERATION

3-1 INTRODUCTION

This chapter describes the operation of the AS210-02 Frequency Comparator. This module works in conjunction with the AS210-01 Module Controller when they are installed in an AS210 system. Figure 3.1 and Table 3-1 illustrate and describe the operator controls, indicators, and connectors of the Frequency Comparator. The operating instructions are essentially identical to those provided in the manual for the Module Controller since most of the operator controls are located on that unit.

3-2 CONTROLS, INDICATORS, AND CONNECTORS

Figure 3.1 illustrates the front panel of the AS210-02, and is indexed to Table 3-1.

3-3 OPERATING PROCEDURES

The following paragraphs and Figure 3.2 are the operating instructions for the Frequency Comparator. Figures in ( ) refer to Figure 3.2 Operational Flow Diagram. Specifically, these instructions tell the operator how to perform frequency error measurements, display measurements from memory, and perform drift calculations. Only the lighted pushbuttons can be used during a routine. CLR is for display clearing only.

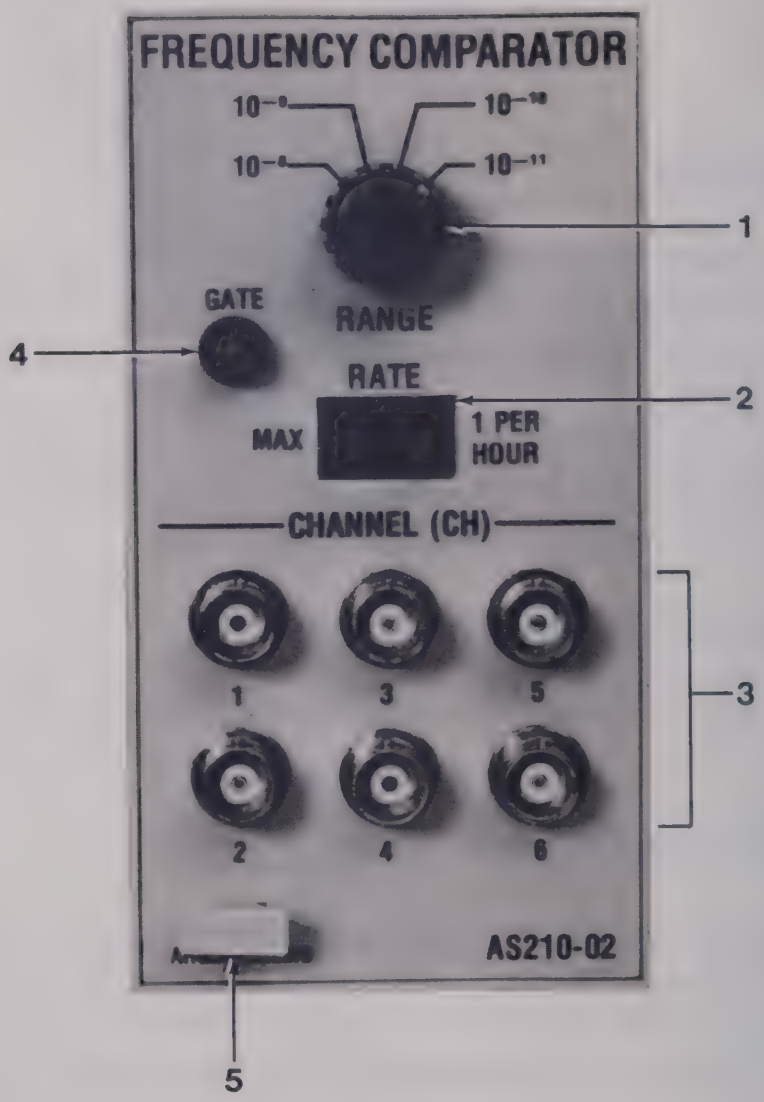

Figure 3.1 AS210-02 Front Panel Controls, Indicators and Connectors

Table 3-1

AS210-02 FRONT PANEL CONTROLS, INDICATORS, AND CONNECTORS

INDEX NO. Figure 3-1	PANEL MARKING	FUNCTION
1	RANGE	Rotary switch for selection of frequency resolution. Four resolutions available: 10^{-8}, 10^{-9}, 10^{-10}, 10^{-11}.
2	RATE	In the MAX position, the Module Controller continuously samples each channel connected (maximum 6) in sequence, starting with channel 1 and ending with the channel selected by the user via the module controller keyboard. In the 1 per hour position, the Module Controller samples once per hour each channel connected (maximum 6) in sequence, starting with channel 1 and ending with the channel selected by the user via the module controller keyboard.
3	CHANNEL (CH)	Input connectors (6) for signals to be measured.
4	GATE	LED indicator lights during the period that counting is taking place, 500 seconds for 10^{-11} resolution, 50 seconds for 10^{-10} resolution, 5 seconds for 10^{-9} resolution, 0.5 seconds for 10^{-8} resolution.
5	None	Release mechanism for removal and retention of module.

FREQUENCY ERROR MEASUREMENT

A. Connect the frequency source to be measured to the front panel BNC connectors on the AS210-02 Frequency Comparator module.

B. Set the RATE switch on the AS210-02 Frequency Comparator module to MAX for continuous sampling or 1 PER HOUR for sample once per hour. The sampling rate is also a function of the resolution selected as follows:

Resolution	Samples per hour in MAX Mode
10^{-8}	Approximately 3600
10^{-9}	Approximately 600
10^{-10}	Approximately 70
10^{-11}	7

The memory of the Module Controller can store 500 samples, therefore the 1 PER HOUR mode may be more useful than the MAX mode when data for several days elapsed time is desired. Up to six inputs can be connected to the Frequency Comparator. For the purposes of this procedure, it is assumed that only channel 1 is being used. When more than one signal is connected, the sequence operates so that each channel is observed for one gate period (a function of the resolution selected), then the next channel is observed. It can be seen that as more inputs are connected, less samples per hour are taken per input when in the MAX mode.

C. Press lighted CONT pushbutton (A) and CH 1-6 should be displayed (B).

D. Enter a channel number from 1 to 6 with the keyboard and press the ENTER function button (C). The number of channels should be

displayed on the LED display. If only one channel is used, channel 1 is automatically selected by the program, by pressing the CONT button.

E. Press CONT (D) and SEL 10^{-} should be displayed (E). Select the desired frequency resolution with the RANGE switch on the AS210-02 Frequency Comparator module.

F. Press CONT (F). The frequency offset measurement routine now proceeds. 0000P-00 will be displayed until the first measurement is made. Thereafter, the channel number and frequency offset (error) will be displayed for each measurement as it is made until 500 measurements have been taken. A display of 1 398P-09 as shown in Figure 3.2 (G) indicates a frequency offset of 398×10^{-9} on channel 1. When 500 measurements have been completed without interruption, the program will halt automatically and 500 oFF will be displayed, indicating that 500 data points have been taken and the program is in an OFF condition. The measurement cycle can also be stopped at any time with the HALT (H) function button. The data point number and oFF will be displayed (I). Measurement can be resumed by pressing CONT.

DISPLAY FREQUENCY MEASUREMENTS FROM MEMORY

A. Press HALT (H) (if program is running) and then DSPL (J). SEL CH should be displayed (K).

B. Select a channel number with the keyboard and press the ENTER function button (L). SEL dP should now be displayed (M).

C. Select a data point number with the keyboard and press the ENTER function button. The number of data points taken during the measurement cycle can be found by pressing DSPL (N). The number of data points and oFF should be displayed (O). For example, 365 oFF. The display will now return to SEL dP (M).

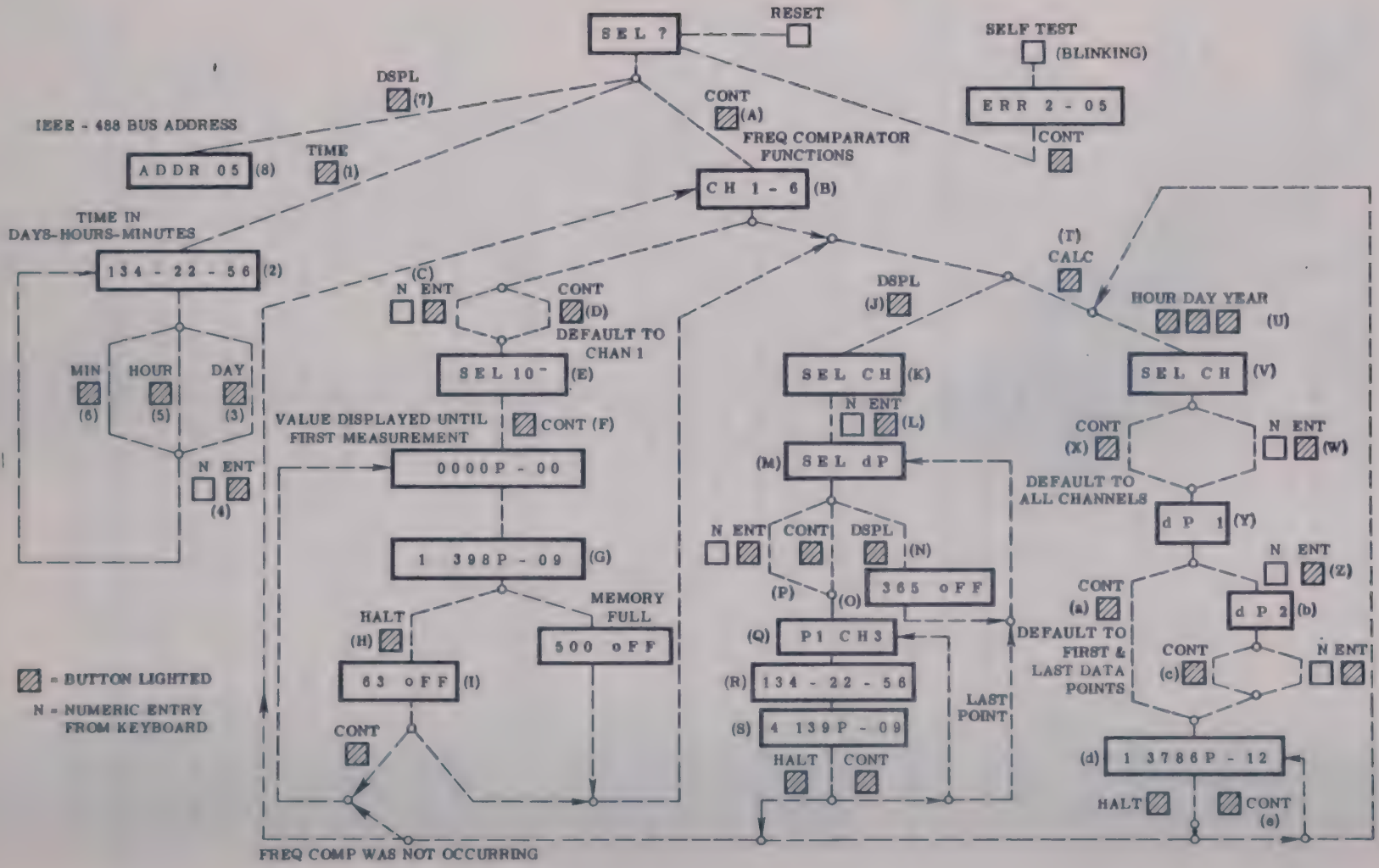

Figure 3.2 Operational Flow Diagram

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D. Press CONT (P) and the display will read out in sequence the data point number and channel number (Q) (e.g., P1 CH 3), then the time the data point measurement was taken (R) (e.g., 134-22-56), then the frequency offset (error) at that data point (S) (e.g., 4 139P-09).

E. The measurement process can be resumed by pressing HALT. If frequency comparisons have not been in progress, the routine will return to (B) and a channel number can be selected.

DRIFT CALCULATIONS

A. At any time after two or more data points have been collected over a time interval of more than 1 minute, a frequency drift calculation can be made.

B. Press HALT, then select the CALC function button (T). Press HOUR, DAY, or YEAR function button (U) to select period for drift calculation.

C. SEL CH will be displayed (V). Select the desired channel number with the keyboard and press the ENTER function button (W). (If CONT is pressed (X), all channels will be computed for frequency drift.)

D. DP 1 will be displayed (Y). Select the desired number for data point one with the keyboard and press the ENTER function button (Z). The number entered can be anything within the data field from 1 to 500, depending on the resolution selected, length of measurement, number of data points, time, etc. If CONT is pressed (a) the drift calculation will automatically be made on the first and last data points. If CONT is not pressed, then dP 2 will be displayed (b). Enter the desired second data point number as with dP 1 (Z).

E. The drift rate will now be displayed for the selected channel (d). For example, 1 3786P-12 indicates a frequency drift over the period of time selected in step 2 of 3786 parts out of 10^{12}.

F. Pressing CONT (e) at this time will return the routine to the point (U) where new time frames, channels, and data points can be selected for a drift calculation.

G. Pressing HALT returns the routine to displaying the frequency offset calculations in process at point (G). If frequency comparisons are not in progress, the routine returns to display CH 1-6 at point (B).

CHAPTER 4
THEORY OF OPERATION

4-1 INTRODUCTION

This chapter describes the theory of operation for the AS210-02 Frequency Comparator. The description is keyed to Figure 4.1, Functional Block Diagram and the schematics in Chapter 5. The three circuit boards are designated A1, A1A1, and A2. Details of common types of circuits (power supplies, etc.) have been omitted. Reference is made in the description to data that comes from and is returned to the CPU. The CPU is located in the AS210-01 Module Controller that is used in conjunction with the Frequency Comparator. Details regarding the operation of the Module Controller may be obtained from the Module Controller manual.

The Frequency Comparator circuit obtains the signal to be measured and compares it with the 10 MHz Rubidium frequency standard. Resolution of Parts in 10^{-11} is achieved through the use of a 200 MHz phase-locked oscillator (PLO) in the counting circuit. The frequency comparator circuits consist of the 10 MHz standard division circuit, input signal conversion circuit, clock circuit, and data processing circuit. The standard input signal can be 0.1, 1, 5, or 10 MHz. Up to six inputs may be accommodated by the AS210-02. The input signal is frequency divided to 100 KHz and used to phase lock the 200 MHz PLO. The PLO signal is gated by the clock enable signal derived from the 10 MHz reference standard. Pulses from the 200 MHz PLO are counted in the accumulator circuit that is periodically scanned by the CPU. Resolution changes are made by varying the clock enable period.

Six input channels are applied to the Input Multiplexer Assembly A1A1. The input select data is obtained from latch A1U10 which holds

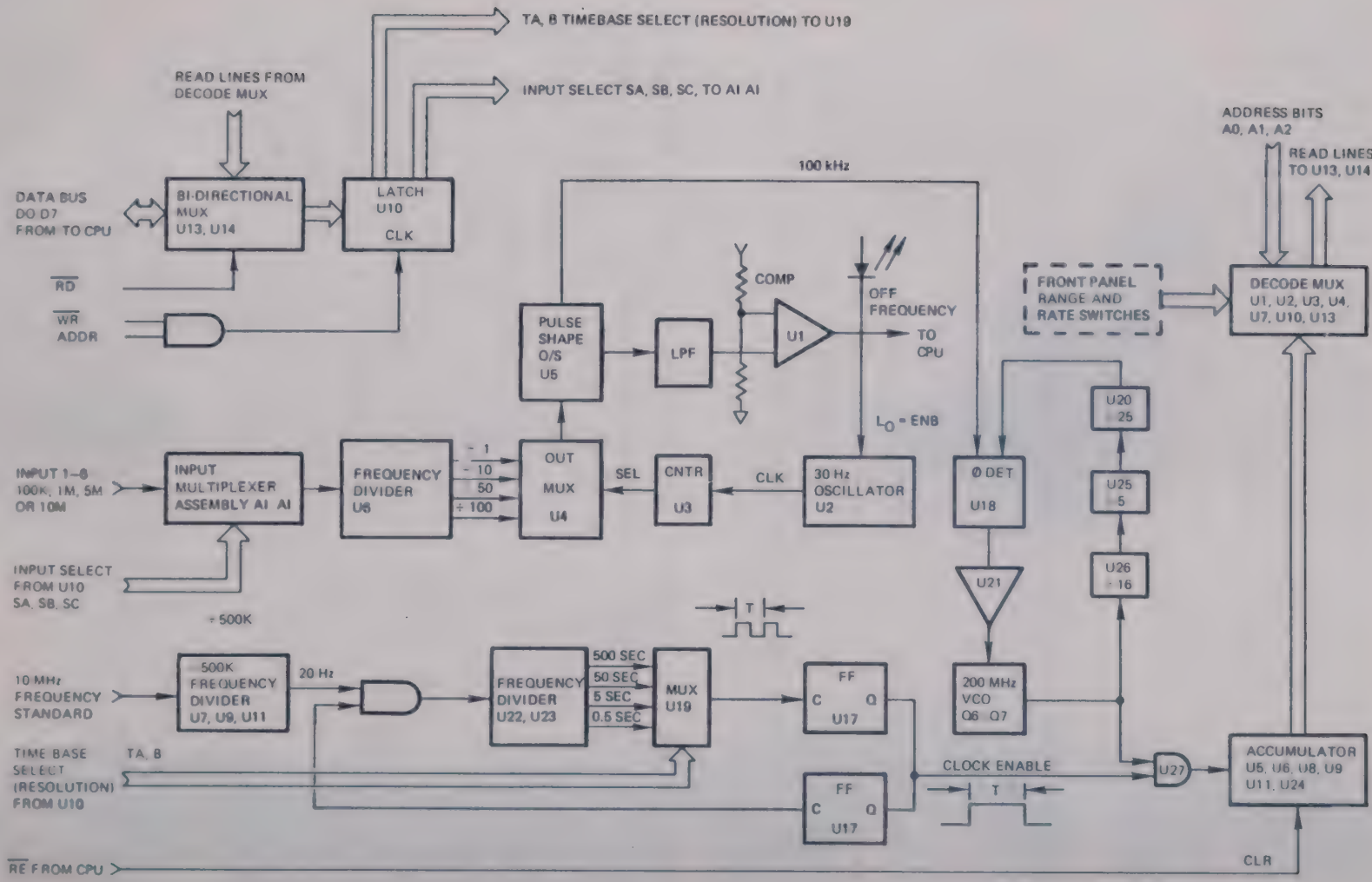


Figure 4.1 Frequency Comparator Functional Block Diagram

information from the Module Controller's CPU selecting the channel to be analyzed. The CPU data is applied to the A1U10 via bidirectional MUX A1U13 and A1U14. This channel number is initially selected by the operator at the Module Controller. The input channels may also be sequentially scanned by the CPU. The Module Controller manual contains more details regarding the CPU operation. The selected input signal is next applied to frequency divider A1U6. The input signal may be 0.1, 1, 5, or 10 MHz. The frequency divider A1U6 contains ÷1, ÷10, ÷50, and ÷100 outputs. A 100 KHz output from A1U6 is desired regardless of the frequency of the input signal. This is achieved by a 100 KHz search circuit consisting of multiplexer A1U4, pulse shaper A1U5, a low pass filter, comparator A1U1, oscillator A1U2, and counter A1U3. The output of A1U4 is pulse shaped by one-shot A1U5 and applied to a low pass filter. The filter's output is a dc voltage that is proportional to frequency. This voltage is applied to the variable input of comparator A1U1. The reference input of A1U1 is set to a voltage that causes the comparator to go high when the variable dc input is equivalent to a 100 KHz signal. When the comparator is low, a ground is provided to an LED that lights to indicate OFF FREQ. The low is also sent to the CPU. While the comparator's output is low (not 100 KHz), a 30 Hz oscillator A1U2, is enabled. The oscillator increments counter A1U3 which sequentially selects inputs to the multiplexer A1U4. The select line sequentially outputs the multiplexer's ÷1, ÷10, ÷50, and ÷100 input until the 100 KHz signal is found. When the line containing the 100 KHz signal is located, the search loop stops as comparator A1U1 goes high, inhibiting A1U2. Assuming an input signal of 1 MHz, the ÷10 multiplex input line will contain the 100 KHz. If the input were 5 MHz, the ÷50 multiplex input line would contain the 100 KHz signal, etc. The 200 MHz VCO, A2Q6, A2Q7 is phase locked to the 100 KHz signal by phase detector A2U18. A2U20, A2U25, and A2U26 divide the 200 MHz signal to 100 KHz. The output of A2U18, filtered and amplified by A2U21, tunes the VCO. Any changes that occur in the input signal are therefore reflected in the output of the 200 MHz VCO. The 200 MHz output is applied to an accumulator circuit consisting of 6 dual decade counters A2U5, A2U6, A2U8, A2U9, A2U11, and A2U24. If the 200 MHz oscillator is gated into the accumulator for 0.5 seconds, 100×10^6 or 10^8 pulses would be counted. This corresponds to a frequency resolution

of 1 x 10^{-8} or 1 pulse out of 10^{8} pulses. Similarly, if the oscillator were gated for periods of 5, 50, or 500 seconds, frequency resolutions of 10^{-9}, 10^{-10}, and 10^{-11} are obtained. In order to provide a precise clock gating period, the 10 MHz Rubidium reference standard signal is divided by 500 in frequency divider A1U7, A1U9, and A1U11. The 20 Hz signal is appied to divider A2U22-A2U23 that has four outputs: ÷10, ÷100, ÷1000, and ÷10000 corresponding to sampling periods of 0.5 seconds, 5 seconds, 50 seconds, and 500 seconds. The four signals are applied to time base multiplexer A2U19. Select lines are obtained from the CPU depending on the resolution selected by the operator at the Module Controller. If, for example, the resolution selected was 10^{-9}, the 5 second period line would be output by the multiplexer. Flip-flop A2U17 goes high on the leading edge of the pulse train and thus provides a 5-second gating pulse for clock gate A2U27. This permits 10^{9} pulses to be counted in the accumulator (provided that the input frequency were exact). The accumulator's output is read by the CPU via a decoding multiplexer (A2U1-A2U4, A2U7, A2U10, A2U13, A2U14). The other inputs to the multiplexers are the front panel RANGE switch and RATE switch. The CPU scans the switches ten times per second to determine the correct data to be applied to the various multiplexers previously described. When a read signal ($\overline{RE}$) is received from the CPU, the accumulator is read and cleared. The $\overline{RE}$ signal also turns off the front panel GATE LED through driver A2Q1. The accumulator's contents are transmitted through the data bus to the Module Controller where calculations are performed. These calculations allow the operator to determine frequency drift over variable periods of time with varying degrees of resolution. This process is explained more fully in the section on operation and in the Module Controller Manual.

CHAPTER 5
MAINTENANCE AND OPERATION

5-1 INTRODUCTION

The purpose of this chapter is to provide maintenance and calibration data for the AS210-02 Frequency Comparator. Section I covers routine preventive maintenance procedures. Section II outlines performance tests for the Frequency Comparator. Section III contains the calibration/alignment procedures for the AS210-02 module, and Section IV describes troubleshooting data. Please contact the factory for any assistance required in the maintenance or servicing of the AS210-02.

SECTION I

5-2 PREVENTIVE MAINTENANCE

Table 5-1 lists preventive maintenance checks and services which should be performed regularly.

Table 5-1
PREVENTIVE MAINTENANCE CHECKS AND SERVICES

ITEM	PROCEDURES
CABLES	Visually inspect cables for strained, cut, frayed, or other damaged insulation.
CLEANLINESS	Make sure the exterior surfaces of the unit are clean. If necessary, clean exterior surfaces as follows: A. Remove the dust and loose dirt with a clean soft cloth. B. Remove dust or dirt from plugs and jacks with a brush. WARNING Use only warm soapy water for cleaning all plastic parts. Many solvents will cause the plastic to become brittle and break.
CORROSION	Make sure exterior surfaces of unit are free of rust and corrosion.
PRESERVATION	Inspect exterior surfaces of the unit for chipped paint or corrosion. If necessary, spot-paint surfaces as follows: A. Remove rust and corrosion from metal surfaces by lightly sanding them with sandpaper. B. Brush two coats of paint on base metal to protect it from further corrosion.

SECTION II

-3 PERFORMANCE TESTING

This section describes the procedure to test the AS210-02 Frequency omparator to assure proper performance of the instrument. The AS210-02 must e used in conjunction with the AS210-01 Module Controller since the CPU in he AS210-01 monitors the controls and operates on the data collected by the S210-02. The AS210-02 Frequency Comparator will not operate without the S210-01 Module Controller installed. If the AS210-02 fails any of the per- ormance tests, please see Section III, Calibration/Alignment procedures and/or ection IV, Troubleshooting procedures in this chapter.

-4 INPUT FREQUENCY PERFORMANCE TESTS

The following is a procedure for testing the input frequency erformance of the AS210-02 frequency comparator. Table 5-2 contains the equired test equipment for this procedure.

Table 5-2
REQUIRED TEST EQUIPMENT FOR THE INPUT FREQUENCY PERFORMANCE TEST

ITEM	RECOMMENDED TEST EQUIPMENT
Frequency Synthesizer	Hewlett-Packard 8656A
Coaxial Cable (2 required)	3 foot long, 50 ohm, BNC
RF Voltmeter	Boonton 92BD OPT 01, 09 with 50 ohm BNC adapter

5-5 TEST PROCEDURE

A. Ensure that power is disconnected from the AS210 system before beginning this procedure.

B. Tune the frequency synthesizer for a 100 KHz signal. Monitor the output of the signal synthesizer with the RF voltmeter and adjust the signal for an output level greater than or equal to 0.5 volts RMS.

C. Connect the equipment as indicated in Figure 5.1 and apply power to the AS210. The Rubidium Frequency Standard in the AS210 system will require 20 minutes warm-up time to reach the specified frequency accuracy.

D. Set the AS210-02 Frequency Comparator RANGE switch to 10^{-8} and set the RATE switch to MAX.

E. Press RESET on the AS210-01 Module Controller. The display of the AS210-01 should indicate "SEL?"

F. Press CONT. The AS210-01 display should indicate "CH 1-6."

G. Press 1, press ENTER. The display should read "SEL 10."

H. Press CONT. The GATE LED on the AS210-02 Frequency Comparator should light for 0.5 second at a time. Monitor the display for 30 seconds. The display should read "1....0P-08" plus or minus 1 part in 10^{-8} during this time.

I. Repeat steps B through H for the frequency synthesizer tuned to 1 MHz, 5 MHz, and 10 MHz.

J. If further verification of proper performance of the AS210-02 Frequency Comparator is desired, this procedure may be repeated for each of the other three RANGE positions (10^{-9}, 10^{-10}, 10^{-11}). Please note that the GATE LED will light for 5 seconds for the 10^{-9} setting, 50 seconds for the 10^{-10} setting, and 500 seconds for the 10^{-11} setting. This procedure may also be run with the RATE switch set on 1-PER-HOUR.

K. Disconnect the frequency synthesizer from the AS210-03.

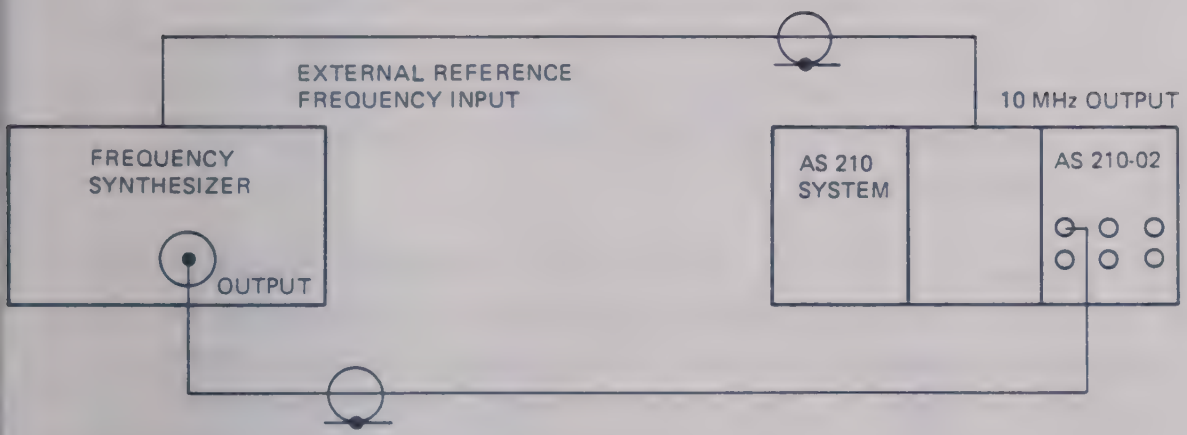


Figure 5.1 AS210-02 Frequency Comparator Input Frequency Performance Test Configuration

SECTION III

5-6 CALIBRATION/ALIGNMENT PROCEDURE

WARNING

The following Calibration/Alignment Procedures (Chapter 5, Section III), and Troubleshooting Procedures (Chapter 5, Section IV) are for use by qualified personnel only. To avoid personal injury, do not perform any servicing other than that of Routine Maintenance (Chapter 5, Section I, and Performance Testing (Chapter 5, Section II) unless you are qualified to do so.

Figure 5.2 is a flow diagram of the Calibration/Alignment Procedure for the AS210-02 Frequency Comparator. Use this flow diagram with the theory of operation in Chapter 4, the text in this chapter, and the illustrated parts lists in Chapter 6. The Rubidium frequency standard calibration procedure which is contained in the AS210 mainframe operation and maintenance manual is also referenced in this flow diagram. Please note it is not necessary to disassemble the AS210 system to determine if the calibration/alignment is needed. For any assistance needed in performing this calibration/alignment procedure, please contact the factory.

5-7 ACCESS TO AS210-02 FREQUENCY COMPARATOR MODULE

Please reference the AS210 mainframe manual for the disassembly procedure of the AS210 system to allow access to the AS210-02 Frequency Comparator module. Access to the module circuitry itself is gained by removing the two metal side covers with a small straight-blade screwdriver. Place the module on one of its sides so that one cover is facing up. Starting with the

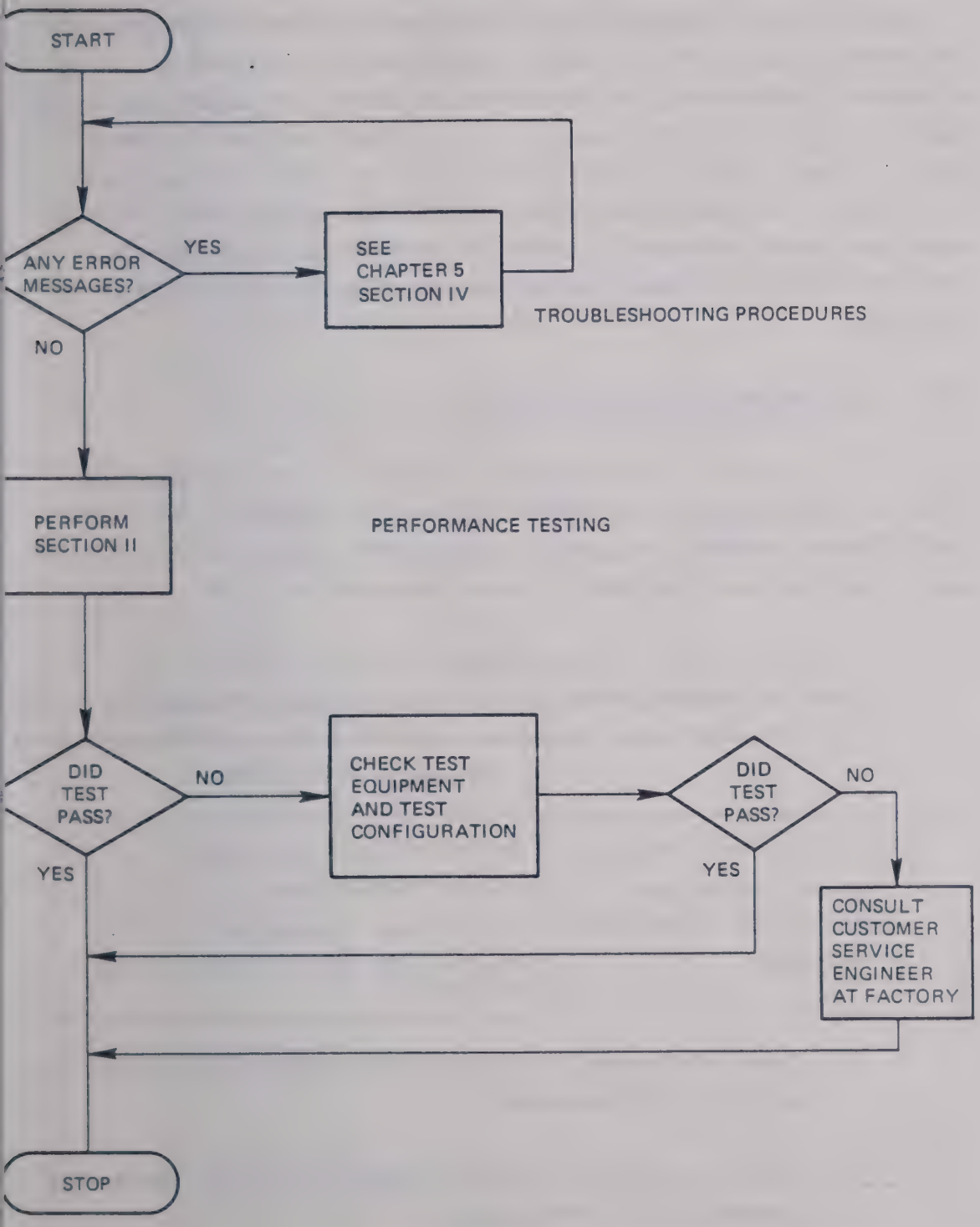


Figure 5.2 Flow Diagram of Calibration/Alignment Procedure for AS210-02 Frequency Comparator

end toward the edge connector, insert the screwdriver into one of the slots where the cover mates with the module chassis and pry the cover up. It will be necessary to move along the slot toward the front panel of the module and repeat the prying action to loosen the side of the cover from the module. Repeat this technique to free the other side of the cover from the chassis. Set the free cover clear of the module and flip the module over so that the second cover is now facing up. Repeat the above procedure to free this cover. The circuit card assemblies are removed from the module by removing four screws.

5-8 200 MHz PLO ALIGNMENT PROCEDURE

The following is the alignment procedure for the 200 MHz phase-locked oscillator (PLO) in the AS210-02 Frequency Comparator. This is the only alignment operation necessary for the AS210-02. Table 5-3 contains the required test equipment for this alignment procedure.

Table 5-3
REQUIRED TEST EQUIPMENT FOR THE 200 MHz PLO ALIGNMENT PROCEDURE

ITEM	RECOMMENDED TEST EQUIPMENT
Oscilloscope with Probes	Tektronix 465 or equivalent
Frequency Synthesizer	Hewlett Packard 8656A
Coaxial Cable (2 required)	3 foot long, 50 ohm, BNC
RF Voltmeter	Boonton 92BD OPT01, 09 with 50 ohm BNC adapter

A. Ensure that power is disconnected from the AS210 system before beginning this procedure.

B. Obtain access to the AS210-02 module circuits by referencing paragraph 5-7 in this chapter.

C. Tune the frequency synthesizer for a 1 MHz signal. Monitor the output of the signal synthesizer with the RF voltmeter and adjust the signal for an output level greater than or equal to 0.5 volts RMS.

D. Connect the equipment as indicated in Figure 5.1 and apply power to the AS210. The Rubidium Frequency Standard in the AS210 system will require 20 minutes warm-up time to reach the specified frequency accuracy.

E. With an Oscilloscope, monitor the DC level at the test point TV* on pin (6) six of A2U21 located on Assembly A2..

F. In a CW direction, adjust A2C8 located on Assembly A2*, until the voltage level passes through a minimum DC level. Continue until the level equals a -4 VDC level.

The AS210-02 Frequency Comparator should now be aligned. To confirm that the Frequency Comparator is operating properly, reference Section II, Performance Testing of the AS210-02, contained in this chapter.

* On units with serial number 178 and above, C8 and test point TV are located on the back side of assembly 117226 for easy access.

SECTION IV

5-9 TROUBLESHOOTING PROCEDURES

Troubleshooting of the Frequency Comparator is facilitated by a combination of error codes displayed on the Module Controller and LED indicators on the two circuit card assemblies. The circuit cards are illustrated in Figures 6.2 (A1) 6.3 (A2), and 6.4 (A1A1). Table 5-4 correlates the error codes, displayed on the Module Controller when a fault occurs, to the malfunction. An explanation of the problem is provided with possible solutions. Table 5-5 is a list of visual indicators on circuit cards A1 and A2 and the meaning of their indications. Figures 5.3, 5.4, and 5.5 are schematic diagrams of assemblies A1, A1A1, and A2, respectively.

Table 5-4

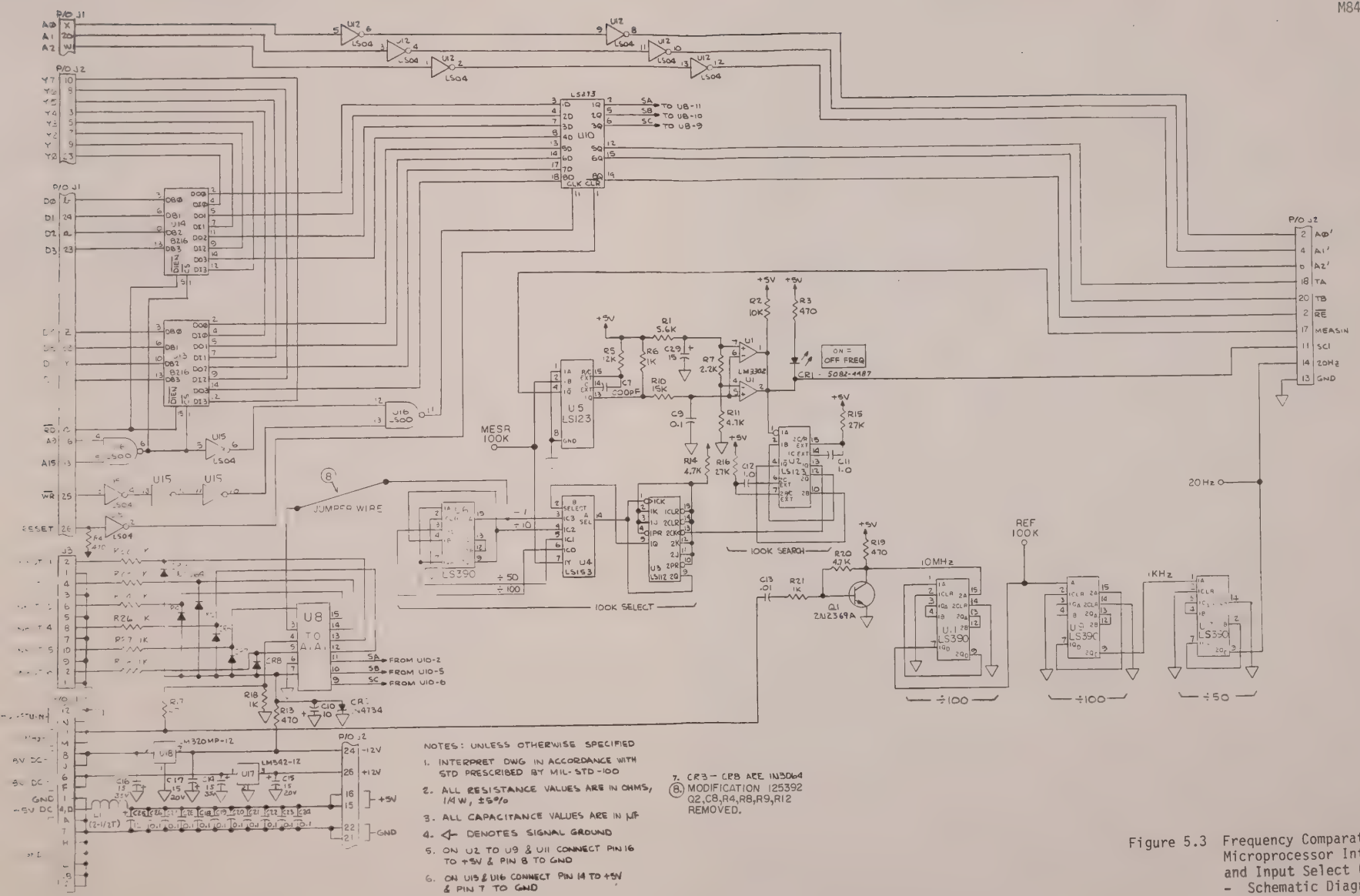
ERROR CODE LISTING

ERROR CODE	PROBLEM	RECOMMENDED SOLUTION
2-01	Output decade registers cannot be cleared	Check A2U5, U6, U9, U11, U15, A1U10, U13, U14, A1A1U1, U2, U3.
2-02	Input selector circuit not working properly (See Table 5-5, A1CR1)	
2-03	Measurement complete, flip flops will not reset	Check A2U17 or A1U10, U13, U14.
2-04	No measurement timebase	Check 10 MHz standard, A1Q1, U11, U9, U7, or A2U15, U23, U22, U19, or U17.
2-05	Self test measurement not within ± 1 part in 10^8.	Check 200 MHz phase lock loop or counters A2U5, U6, U9, U11, A1A1U1, U2, U3. See paragraph 5-14.
2-11 to 2-16	No signal present at indicated (1-6) input or signal output is not one of the allowable standard frequencies	Check input signal and input signal frequency on the indicated input.
2-20	Data points selected for drift rate calculation are separated by less than 1 minute.	Choose new data points accuracy of drift rate calculation improved by increasing time between measurements.
2-21	Data points separated by discontinuous time (power failure without battery backup of frequency standard).	
2-22	Initial data point in drift rate calculation overflowed.	
2-23	Final data point overflowed.	
2-30	Channel number specified has no data associated with it.	
2-40	Data point specified is empty.	
2-50	Remote continue comand with module in standby mode.	

Table 5-5

VISUAL INDICATORS

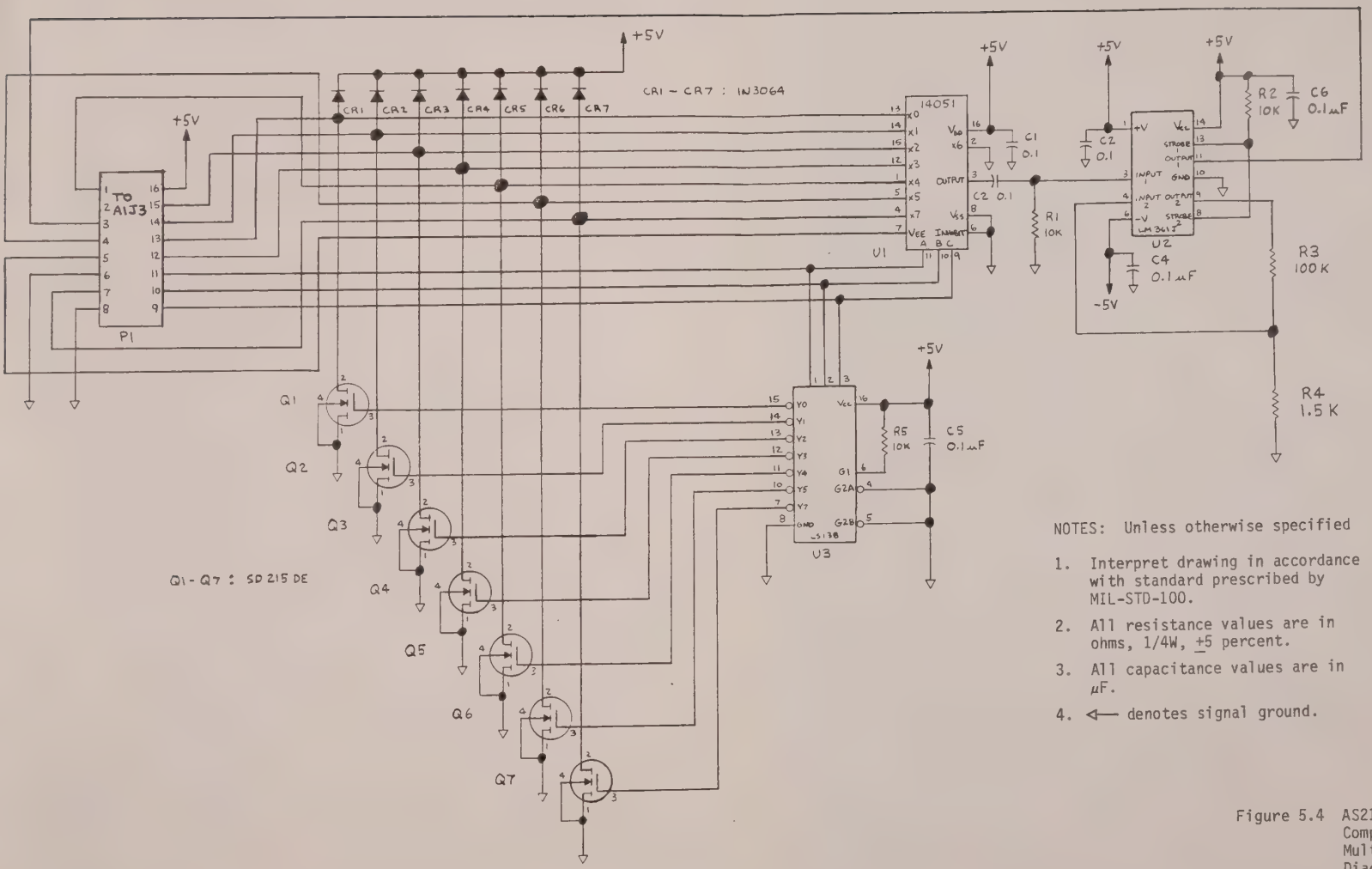
INDICATOR	PROBLEM	RECOMMENDED SOLUTION
A1CR1 ON	Off frequency. Input selector malfunction.	Check A1A1, U6, U5, U1, U4, U2, or U3.
A2CR1 ON	Unlock. 200 MHz oscillator malfunction.	Check A2Q6, Q7, or A2U18, U20, U25, Q8, U26, U27, U21. See paragraph 5-8.



NOTES: UNLESS OTHERWISE SPECIFIED

1. INTERPRET DWG IN ACCORDANCE WITH STD PRESCRIBED BY MIL-STD-100
2. ALL RESISTANCE VALUES ARE IN OHMS, 1/4W, ±5%
3. ALL CAPACITANCE VALUES ARE IN μF
4. ⏚ DENOTES SIGNAL GROUND
5. ON U2 TO U9 & U11 CONNECT PIN 16 TO +5V & PIN 8 TO GND
6. ON U15 & U16 CONNECT PIN 14 TO +5V & PIN 7 TO GND
7. CR3 - CP8 ACE 1N3064
8. MODIFICATION 125392 Q2,C8,R4,R8,R9,R12 REMOVED.

Figure 5.3 Frequency Comparator, Microprocessor Interface and Input Select (A1) - Schematic Diagram



NOTES: Unless otherwise specified

1. Interpret drawing in accordance with standard prescribed by MIL-STD-100.
2. All resistance values are in ohms, 1/4W, ±5 percent.
3. All capacitance values are in μF.
4. ⏚ denotes signal ground.

Figure 5.4 AS210-02 Frequency Comparator Input Multiplexer Schematic Diagram, A1A1

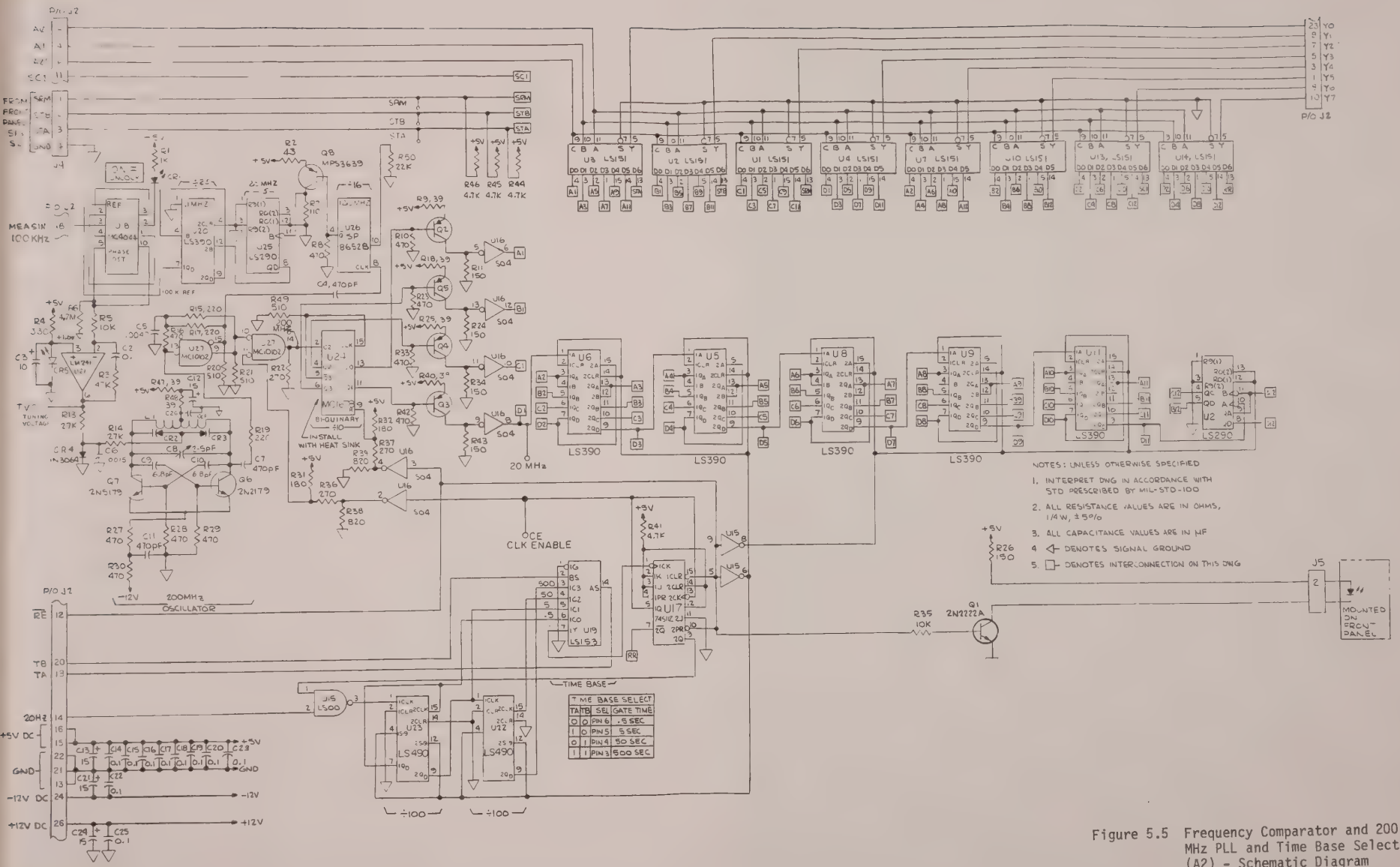


Figure 5.5 Frequency Comparator and 200 MHz PLL and Time Base Select (A2) - Schematic Diagram

CHAPTER 6
ILLUSTRATED PARTS LIST

6-1 INTRODUCTION

This chapter contains an illustrated parts list for the AS210-02 Frequency Comparator Module. The assembly numbers and assembly title are listed at the top of the parts lists. The parts lists are divided into six columns and arranged in the following order:

Column 1 - Item Number

Column 2 - Quantity per assembly.

Column 3 - Manufacturer's Code

Column 4 - Part Number

Column 5 - Description

Column 6 - Reference Designation

ASSEMBLY NUMBER 117169-01 - FREQUENCY COMPARATOR AS-210-02

ITEM	QTY	MANUFAC-TURER'S CODE	PART NUMBER	DESCRIPTION	REF. DESIG.
1	1	33472	117220-01	Frequency Comparator Assembly A1	
2	1	33472	117225-01	Frequency Comparator Assembly A2	
3	4	06540	8225-SS-0632	Standoff, 6-32 Thread 1-1/4	
4	2	81349	NAS662-C2R8	Screw, FLH 2-56X1/2	
5	0	33472	117326	Frame Section Modification	
6	1	33472	117351-01	Cable Assembly	
7	8	81349	MS51957-27	Screw, PH 6-32X5/16	
8	8	81349	NAS620-C6	Reduced OD Flat Washer #6	
9	8	81349	MS35338-136	Split Lock Washer #6	
10	1	33472	117181-01	Panel, Front, Lexan	
11	1	95146	PKG-50B1/4	Knob, Black	
12	1	33472	117188	Switch, Rotary 30 Degree	
13	1	09353	7101-J1-ZQ	Rocker Switch, SPDT	
14	6	91836	KC-79-35	BNC Bulkhead, Receptacle	
15	1	03797	Q086-13D	Socket, LED	
16	1	50434	5082-4957	LED	
17	0	81349	RG178	Coax Cable, 50 ohm	
18	1	27264	22-01-2121	Connector, Plug, 12 Pin	
19	1	27264	22-01-2041	Connector, Plug 4 Pin	
20	1	27264	22-01-2021	Connector, Plug 2 Pin	
21	18	27264	08-50-0114	Pin, Crimp	
22	6	83330	1497	Ground Lug	
23	0	33472	117194	Wire List	
24	1	33472	117181-02	Subpanel, Plastic	

SSEMBLY NUMBER 117169-01 - FREQUENCY COMPARATOR AS-210-02 (Continued)

ITEM	QTY	MANUFACTURER'S CODE	PART NUMBER	DESCRIPTION	REF. DESIG.
25	1	33472	117181-03	Panel, Rear	
26	0	81349	ET 26 AWG	Wire Stranded Teflon Insulated	
27	1	80009	366-1690-01	Latch Pull	
28	1	33472	117181-03	Subpanel, Metal	
29	1	80009	105-0718-01	Latch	
30	1	80009	105-0719-00	Latch Retainer	
31	1	80009	426-0724-00	Bottom	
32	2	80009	337-1399-00	Side Cover	
33	1	80009	214-1061-00	Tension Spring	
34	1	80009	426-0725-00	Top	
35	2	80009	386-3657-01	Guide Pin	
36	1	81349	00000000	Screw, FLH, STL, Sheetmetal #2X1/4	
37	4	81349	MS24693-C26	Screw, FLH, 6-32X3/8	
38	4	81349	00000000	Screw, PNH, STL, Sheetmetal, #6X3/8	

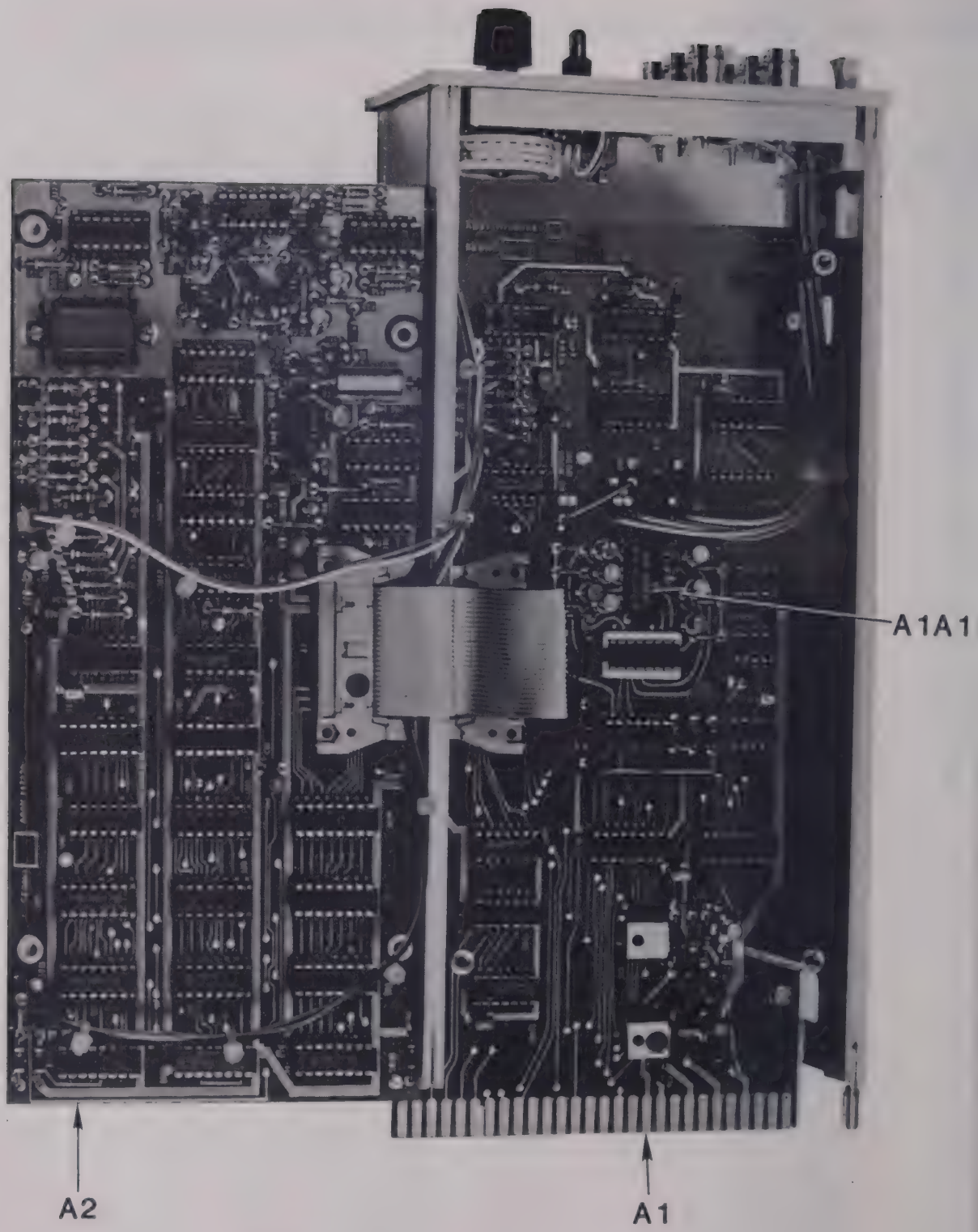


Figure 6.1 Frequency Comparator Module

ASSEMBLY NUMBER 117220-01 - FREQUENCY COMPARATOR A1

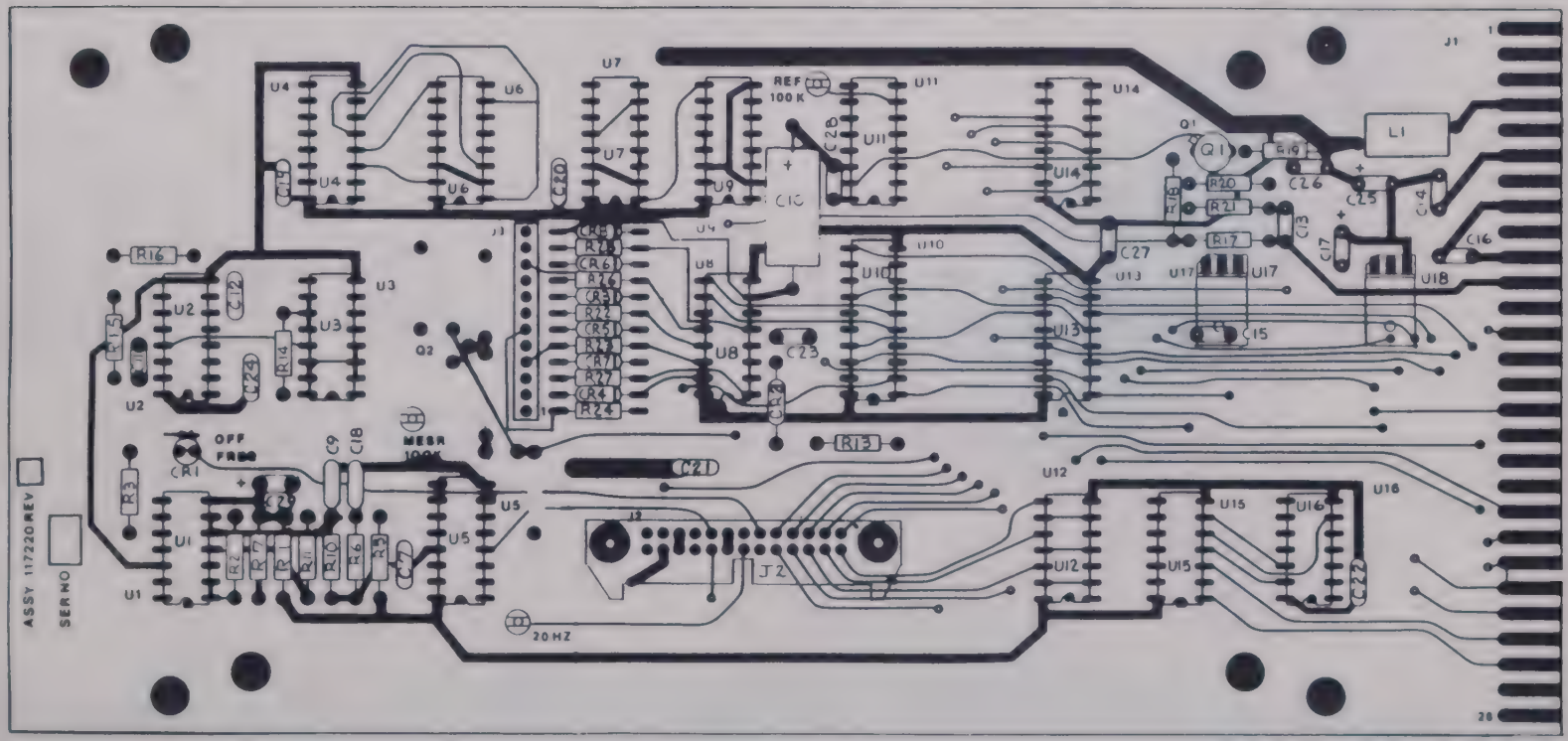
ITEM	QTY	MANUFACTURER'S CODE	PART NUMBER	DESCRIPTION	REF. DESIG.
1	1	33472	117223-01	PWB	
2	0	33472	117221	Schematic	
3	0	33472	117220	Assembly Drawing	
4	1	81349	CK05BX102K	.001 UFD 10% Ceramic Capacitor	C7
5	1	81349	CK05BX103K	.01 UFD 10% Ceramic Capacitor	C13
6	11	81349	CK05BX104K	.1 UFD 10% Ceramic Capacitor	C9,C16-24, C26-28
7	2	51642	300-50-601-105M	1 UFD 20% Ceramic Capacitor	C11-12
8	1	81349	CSR13G106KL	10 UFD, 50V, Electrolytic Capacitor	C10
9	2	56289	196D156X 9020KA1	15 UFD, 10% Solid Tantalum Capacitor	C25,C29
10	3	15849	2010B-1	Terminal	
11	1	50434	5082-4487	Light Emitting Diode	CR1
12	1	04713	1N4734	5.2V Zener Diode	CR2
13	6	27014	1N3064	Diode	CR3-8
14	1	53387	3429-1202	26 Pin PC Mount Male Header	J2
15	1	27264	22-03-2121	Wafer, 12 Pin	J3
16	1	02114	VK200-20/4B	Wide Band Choke	L1
17	1	27014	2N2369A	NPN Transistor	Q1
18	9	81349	RCR07G102JS	1K 5% 1/4W Carbon Comp	R6,R18,R21, R22-24, R26-28
19	1	81349	RCR07G103JS	10K 5% 1/4 Carbon Comp	R2
20	2	56289	196D156X 9020KA1	15 MFD 20V Tant	C15,C17

ASSEMBLY NUMBER 117220-01 - FREQUENCY COMPARATOR A1 (Continued)

ITEM	QTY	MANUFAC-TURER'S CODE	PART NUMBER	DESCRIPTION	REF. DESIG.
21	2	56289	196D156X 9035PE4	15 MFD 35V Tant	C14,C16
22	1	81349	RCR07G123JS	12K 5% 1/4W Carbon Comp	R5
23	1	81349	RCR07G153JS	15K 5% 1/4W Carbon Comp	R10
24	1	81349	RCR07G222JS	2.2K 5% 1/4W Carbon Comp	R7
25	2	81349	RCR07G273JS	27K 5% 1/4W Carbon Comp Comp	R15,R16
26	4	81349	RCR07G471JS	470 5% 1/4W Carbon Comp	R3,R8,R13, R17,R19
27	2	81349	RCR07G472JS	4.7K 5% 1/4W Carbon Comp	R11,R14,R20
28	1	81349	RCR07G562JS	5.6K 5% 1/4W Carbon Comp	R1
29	1	27014	LM320MP-12	12V Regulator	U18
30	1	27014	LM342P-12	12V Regulator	U17
31	1	27014	LM3302N	Dual Comp	U1
32	1	01295	74LS00N	Quad 2 Input NAND Gate	U16
33	2	01295	74LS04N	Hex Inverter	U12,U15
34	1	01295	74LS112N	Dual JK Flip Flop	U3
35	2	01295	74LS123N	Dual One Shot	U2,U5
36	1	01295	74LS153N	Multiplexer	U4
37	1	01295	74LS273N	Octal D Flip Flop	U10
38	4	01295	74LS390N	Decade Counter	U6,U7,U9, U11
39	1	33472	125383	A1A1, Input Analog Multiplexer	U8
40	2	34649	P8216	Bus Driver	U13,U14

SSEMBLY NUMBER 117220-01 - FREQUENCY COMPARATOR A1 (Continued)

ITEM	QTY	MANUFACTURER'S CODE	PART NUMBER	DESCRIPTION	REF. DESIG.
41	4	01295	C9314-02	14 Pin Socket	
42	11	01295	C9316-02	16 Pin Socket	
43	1	01295	C9320-02	20 Pin Socket	



COMPONENT SIDE

Figure 6.2 AS210-02 Frequency Comparator Microprocessor Interface and Input Select Assembly, A1

ASSEMBLY NUMBER 117225-01 - FREQUENCY COMPARATOR AS-210-02

ITEM	QTY	MANUFACTURER'S CODE	PART NUMBER	DESCRIPTION	REF. DESIG.
1	1	33472	117228-01	PWB	
2	0	33472	117226	Schematic	
3	0	33472	117225	Assembly Drawing	
4	11	81349	CK05BX104K	.1 UFD 10% Ceramic Capacitor	C2,C14-20, C22,C23,C25
5	1	81349	CK05BX152K	.0015 UFD 10% Ceramic Capacitor	C6
6	2	81349	CK05BX472K	470 PFD 10% Ceramic Capacitor	C4,C7,C11
7	1	81349	CK05BX472K	.0047 UFD 10% Ceramic Capacitor	C5
8	4	56289	196D156X 9020KA1	15 UFD 10% Solid Tantalum Capacitor	C12,C13,C21, C24
9	1	81349	CSR13G106KL	10 UFD 50V Electrolytic Capacitor	C3
10	1	72982	513-010-A2-10	2-10 PFD Variable Capacitor	C8
11	2	51642	100-100C0G-689J	6.8 PFD 5% Ceramic Capacitor	C9,C10
12	7	15849	2010B-1	Terminal	
13	2	50434	5082-4487	Light Emitting Diode	CR1,CR5
14	2	04713	MV2203	Tuning Diode	CR2,CR3
15	1	27014	1N3064	Diode	CR4
16	1	53387	3429-1202	26 Pin PC Mount Connector	J2
17	1	27264	22-03-2021	2 Pin Wafer	J5
18	1	27264	22-03-2041	4 Pin Wafer	J4
19	1	13103	6007A	Heat Sink Base and Cap	
20	1	33472	117305-10	Inductor	L1
21	2	81349	MS51957-4	Screw, PNH, 2-56X5/16	
22	2	81349	NAS620-C2	Reduced OD Flat Washer #2	

ASSEMBLY NUMBER 117225-01 - FREQUENCY COMPARATOR AS-210-02 (Continued)

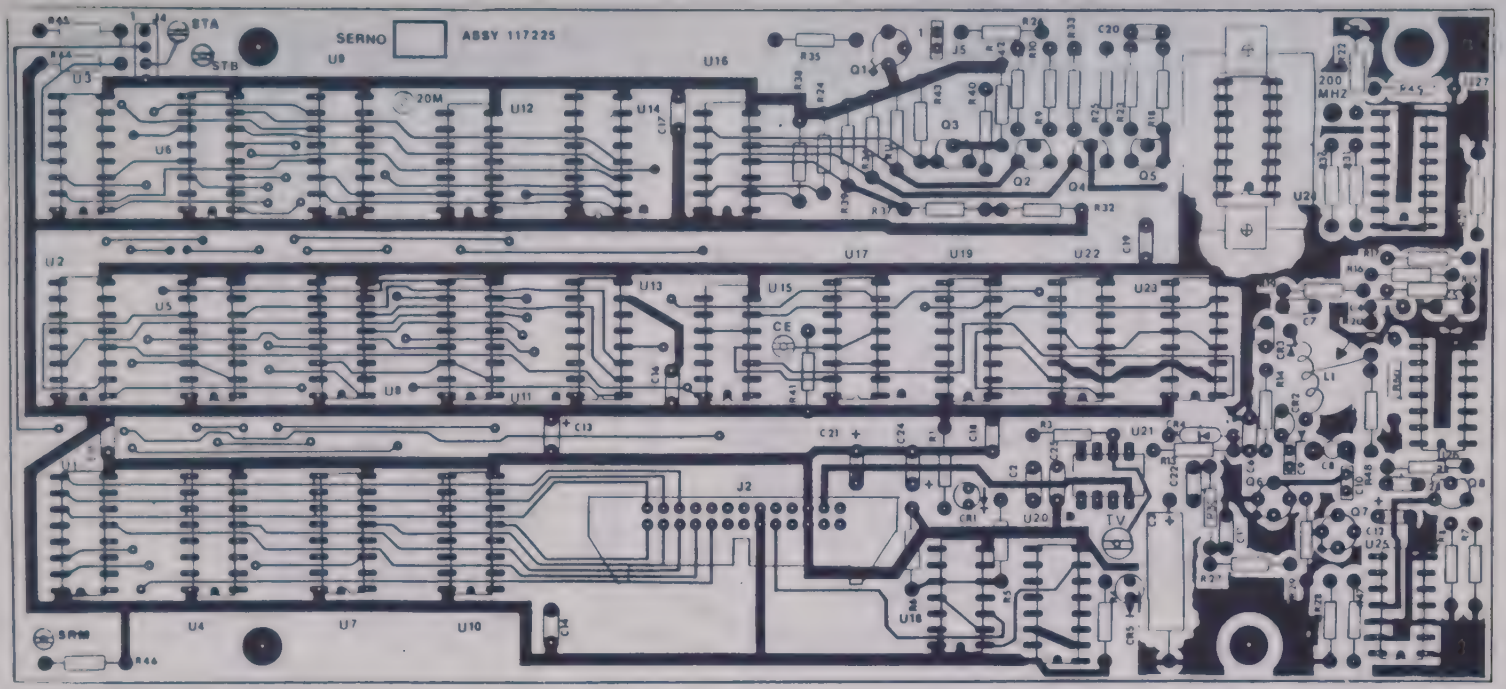
ITEM	QTY	MANUFAC-TURER'S CODE	PART NUMBER	DESCRIPTION	REF. DESIG.
23	2	81349	MS35338-134	Split Lock Washer #2	
24	2	81349	NAS671-C2	Small Pattern Hex Nut #2	
25	1	27014	2N2222A	NPN Transistor	Q1
26	2	04713	2N5179	NPN Transistor	Q6,Q7
27	5	04713	MPS3639	PNP Transistor	Q2-5,Q8
28	1	81349	RCR07G102JS	1K ohm 5% 1/4W Carbon Comp	R1
29	2	81349	RCR07G103JS	10K ohm 5% 1/4W Carbon Comp	R5,R35
30	1	81349	RCR05G475JS	4.7 MEG ohm 5% 1/8W Carbon Comp	R6
31	5	81349	RCR07G151JS	150 ohm 5% 1/4W Carbon Comp	R11,R24,R26, R34,R43
32	1	81349	RCR07G223JS	22K ohm 5% 1/4W Carbon Comp	R50
33	3	81349	RCR07G221JS	220 ohm 5% 1/4W Carbon Comp	R15,R17,R19
34	2	81349	RCR07G273JS	27K ohm 5% 1/4W Carbon Comp	R13,R14
35	6	81349	RCR07G390JS	39 ohm 5% 1/4W Carbon Comp	R9,R18,R25, R40,R47,R48
36	1	81349	RCR07G331JS	330K ohm 5% 1/4W Carbon Comp	R4
37	10	81349	RCR07G471JS	470 ohm 5% 1/4W Carbon Comp	R8,R10,R16, R23,R27-30, R33,R42
38	3	81349	RCR07G511JS	510 ohm 5% 1/4W Carbon Comp	R20,R21,R49
39	1	81349	RCR07G430JS	43 ohm 5% 1/4W Carbon Comp	R2

ASSEMBLY NUMBER 117225-01 - FREQUENCY COMPARATOR AS-210-02 (Continued)

ITEM	QTY	MANUFAC-TURER'S CODE	PART NUMBER	DESCRIPTION	REF. DESIG.
40	1	81349	RCR07G131JS	130 ohm 5% 1/4W Carbon Comp	R22
41	1	81349	RCR07G473JS	47K ohm 5% 1/4W Carbon Comp	R3
42	1	81349	RCR07G111JS	110 ohm 5% 1/4W Carbon Comp	R7
43	2	81349	RCR07G181JS	180 ohm 5% 1/4W Carbon Comp	R31,R32
44	2	81349	RCR07G271JS	270 ohm 5% 1/4W Carbon Comp	R36,R37
45	4	81349	RCR07G472JS	4.7K ohm 5% 1/4W Carbon Comp	R41,R44-46
46	2	81349	RCR07G821JS	820 ohm 5% 1/4W Carbon Comp	R38,R39
47	1	01295	74LS00N	Quad 2 Input NAND Gate	U15
48	1	01295	74S04N	Hex Inverter	U16
49	1	01295	74S112N	Dual JK Flip Flop	U17
50	8	01295	74LS151N	7 to 1 Multiplixer	U1-4,U7,U10, U13,U14
51	1	01295	74LS153N	Multiplexer	U19
52	2	01295	74LS290N	Decade Counter	U12,U25
53	6	01295	74LS390N	Decade Counter	U5,U6,U8,U9, U11,U20
54	2	01295	74LS490N	Decade Counter	U22,U23
55	1	04713	MC10102P	Quad 2 Input NAND Gate	U27
56	1	04713	MC1678P	Decade Counter	U24
57	1	04713	MC4044P	Phase Comparator	U18
58	1	27014	LM741CN	Comparator	U21
59	1	55154	SP8650B	Decade Counter	U26
60	6	01295	C9314-02	14 Pin Socket	

ASSEMBLY NUMBER 117225-01 - FREQUENCY COMPARATOR AS-210-02 (Continued)

ITEM	QTY	MANUFACTURER'S CODE	PART NUMBER	DESCRIPTION	REF. DESIG.
61	19	01295	C9316-02	16 Pin Socket	
62	1	01295	C9308-02	8 Pin Socket	
63	1	81349	CM04CD100-J03	10 PFD Silver Mica Cap	C26

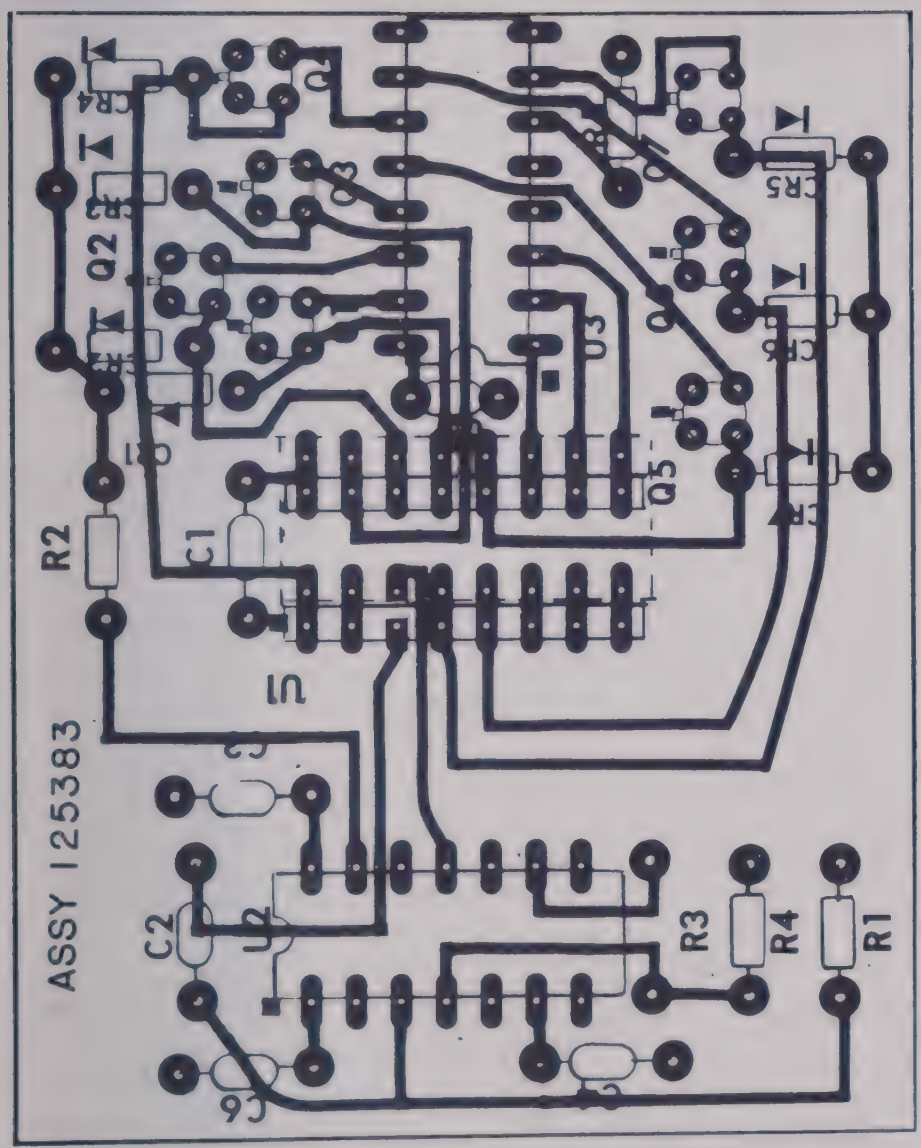


COMPONENT SIDE

Figure 6.3 AS210-02 Frequency Comparator 200 MHz Phase-Locked Oscillator and Time Base Select Assembly, A2

ASSEMBLY NUMBER 125383-01 - INPUT SWITCHING ASSEMBLY A1A1

ITEM	QTY	MANUFACTURER'S CODE	PART NUMBER	DESCRIPTION	REF. DESIG.
1	1	33472	125388	PWB	
2	0	33472	125385	Schematic	
3	0	33472	125383-01	Assembly Drawing	
4	1	04713	MC14051B	3-8 Decoder	U1
5	1	27014	LM361N	Comparator	U2
6	1	01295	74LS138N	Decoder	U3
7	1	91506	616-AG16	16 Pin Component Adapter	P1
8	3	81349	RCR05G103JS	10K ohm 5% 1/8W Carbon Comp	R1,R2,R5
9	1	81349	RCR05G104JS	100K ohm 5% 1/8 Carbon Comp	R3
10	1	81349	RCR05G152JS	1.5K ohm 5% 1/8W Carbon Comp	R4
11	7	27014	SD215	FET	Q1,Q2,Q3, Q4,Q5,Q6, Q7
12	7	04713	1N3064	Diode	CR1,CR2,CR3 CR4,CR5,CR6, CR7
13	5	81349	CK05BX104K	.1 UFD 10% Ceramic Capacitor	C1,C3,C4,C5, C6
14	1	81349	CK05BX103K	.01 UFD 10% Ceramic Capacitor	C2
15	1	01295	C9316-02	16 Pin Socket	
16	1	01295	C9314-02	14 Pin Socket	
17	28	09769	2-331272-6	Mini Pins	
18	2	09769	1-583773-5	8 Pin Inline Socket	



COMPONENT SIDE

Figure 6.4 AS210-02 Frequency Comparator Input Multiplexer Assembly, A1A1

ASSEMBLY NUMBER 117351-01 - CABLE ASSEMBLY

ITEM	QTY	MANUFACTURER'S CODE	PART NUMBER	DESCRIPTION	REF. DESIG.
1	2	53387	3399-6000	Connector, 26 Pin	
2	6	53387	3365/26	Cable, 26 Wire, Ribbon	

6-2 MANUFACTURER'S LIST CODE TO NAME

This section contains all manufacturer's codes for materials used in the AS210 system. The codes are listed in numerical order by code.

MANUFACTURER'S LIST CODE TO NAME

CODE	MANUFACTURER	ADDRESS
00779	AMP, INC	P.O. Box 3608 Harrisburg, PA 17105
01121	ALLEN-BRADLEY COMPANY	1202 South 2nd Street Milwaukee, WI 53204
01139	GENERAL ELECTRIC COMPANY	Silicone Products Business Department Waterford, NY 12188 PHONE: 518-237-3330
01281	TRW, INC.	TRW Semiconductor Division 14520 Aviation Boulevard Lawndale, CA 90260
01295	TEXAS INSTRUMENTS, INC.	Semiconductor Group 13500 North Central Expressway P.O.Box 225012 M/S 49 Dallas, TX 75265
02114	AMPEREX ELECTRONIC CORPORATION	Ferroxcub Division 5083 Kings Highway Saugerties, NY 12477
02660	BUNKER RAMO-ELTRA CORPORATION	Amphenol Division 2801 South. 25th Avenue Broadview, IL 60153
02735	RCA CORPORPATION	Solid State Division Route 202 Somerville, NJ 08876
03797	GENISCO TECHNOLOGY CORPORATION	Electronics Division 18435 Susana Road Rancho Dominguez, CA 90221 PHONE: 213-537-4750
04426	ILLINOIS TOOL WORKS, INC.	Licon Division 6615 West Irving Park Road Chicago, IL 60634
04713	MOTOROLA, INC.	Semiconductor Products Sector 5005 East McDowell Road Phoenix, AZ 85008 PHONE: 602-244-7100

ODE	MANUFACTURER	ADDRESS
5245	CORCOM, INC.	1600 Wincheste Road Libertyville, IL 60048
6090	RAYCHEM CORPORATION	300 Constitution Drive Menlo Park, CA 94025
6383	PANDUIT CORPORATION	17301 Ridgeland Tinley Park, IL 60477
6540	MITE CORPORATION	Amatom Electronic Hardware Division 446 Blake Street New Haven, CT 06515
7263	FAIRCHILD CAMERA & INSTRUMENT CORPORATION	Sub of Schlumberger LTD North American Sales Mail Stop 14-1053 401 Ellis Street P. O. Drawer 7284 Mt. View, CA 94042
9353	C AND K COMPONENTS, INC.	15 Riverdale Avenue Newton, MA 02158 PHONE: 617-964-6400
11237	CTS KEENE, INC.	P.O. Box 1977 Paso Robles, CA 93446
12136	PHC INDUSTRIES, INC.	1643 Haddon Avenue Camden, NJ 08103
13103	THERMALLOY COMPANY, INC.	2021 West Valley View Lane P. O. Box 340839 Dallas, TX 75234
13556	TRW CINCH CONNECTORS	Nuline Facility Division of TRW, Inc. New Hope, MN
14099	SEMTECH CORPORATION	652 Mitchell Road Newbury Park, CA 91320 PHONE: 213-628-5392
14655	CORNELL-DUBILIER ELECTRONICS	Div. of Federal Pacific Electric Co. Government Contracts Department 150 Avenue L Newark, NJ 07101

CODE	MANUFACTURER	ADDRESS
15542	MINI-CIRCUITS LABORATORY	Div. of Scientific Components Corp. 2625 East 14th Street Brooklyn, NY 11235
16428	BELDEN ELECTRONIC WIRE & CABLE	Sub of Cooper Industries, Inc. 2200 U.S. Highway 27 South P.O. Box 1980 Richmond, IN 47374 PHONE: 317-983-5200
18612	VISHAY INTERTECHNOLOGY, INC.	Vishay Resistor Products Division 63 Lincoln Highway Malvern, PA 19355
19209	GENERAL ELECTRIC COMPANY	Battery Business Department 441 Highway N P. O. Box 861 Gainesville, FL 32602 PHONE: 904-462-3911
23936	PAMOTOR DIVISION OF WILLIAM J. PURDY COMPANY	770 Airport Boulevard Burlingame, CA 94010
26805	OMNI SPECTRA, INC.	Microwave Connector Division Waltham, MA
26806	AMERICAN ZETTLER, INC.	16881 Hale Avenue Irvine, CA 92714
27014	NATIONAL SEMICONDUCTOR CORPORATION	2900 Semiconductor Drive Santa Clara, CA 95051
27264	MOLEX, INC.	2222 Wellington Court Lisle, IL 60532
32997	BOURNS, INC.	Trimpot Division 1200 Columbia Avenue Riverside, CA
33472	ARGOSYSTEMS, Inc.	884 Hermosa Court Sunnyvale, CA 94086
34649	INTEL CORPORATION	3585 SW 198th Avenue Aloha, OR 97005

CODE	MANUFACTURER	ADDRESS
50088	MOSTEK CORPORATION	Sub of United Technologies Corp. 1215 West Crosby Road P.O. Box 169 Carrollton, TX 75006
50434	HEWLETT-PACKARD COMPANY	Optoelectronics Division 640 Page Mill Road Palo Alto, CA 94304
51642	CENTRE ENGINEERING, INC.	2820 E. College Avenue State College, PA 16801
53387	MINNESOTA MINING AND MANUFACTURING COMPANY	Electronic Products Division 3M Center St. Paul, MN 55101
54893	HEWLETT-PACKARD COMPANY	Microwave Semiconductor Division 350 West Trimble Road San Jose, CA 95131
55154	PLESSEY PERIPHERAL SYSTEMS, INC.	17466 Daimler Avenue P. O. Box 19616 Irvine, CA 92714
55566	R A F ELECTRONIC HARDWARE, INC.	95 Silvermine Road Seymour, CT 06483 PHONE: 203-888-2133
56289	SPRAGUE ELECTRIC COMPANY	87 Marshall Street North Adams, MA 01247
58910	ABBOTT TRANSISTOR LABORATORIES, INC.	Transformer Division 639 South Glenwood Place Burbank, CA 91506
59660	TUSONIX, INC.	2155 North Forbes Boulevard Suite 107 Tucson, AZ 85745
59705	STANDEX INTERNATIONAL CORPORATION	United Service Equipment Co. Div. 1152 Park Avenue Murfreesboro, TN 37130

CODE	MANUFACTURER	ADDRESS
71279	MIDLAND-ROSS CORPORATION	Cambion Division One Alewife Place Cambridge, MA 02140 PHONE: 617-491-5400
71450	CTS CORPORATION	905 North West Boulevard Elkhart, IN 46514
71984	DOW CORNING CORPORATION	3901 South Saginaw Road Midland, MI 48640
73138	BECKMAN INSTRUMENTS, INC.	Helipot Division Sub of Smith Kline/Beckman Corp. 2500 Harbor Boulevard Fullerton, CA 92634
75915	TRACOR LITTLEFUSE, INC.	800 East Northwest Highway Des Plaines, IL 60016
77969	RUBBERCRAFT CORPORATION OF CALIFORNIA LTD.	1800 West 220th Street P.O. Box B Torrance, CA 90507 PHONE: 213-328-5402
78277	SIGMA INSTRUMENTS, INC.	170 Pearl Street South Braintree, MA 02184 PHONE: 617-853-5000
80009	TEKTRONIX, INC.	4900 Southwest Griffith Drive P. O. Box 500 Beaverton, OR 97077
81349	MILITARY SPECIFICATIONS	Promultgated by Military Departments/Agencies Under Authority of Defense Standard- ization Manual 4120 3-M
83330	SMITH HERMAN H. INC.	A North American Philips Company 1913 Atlantic Avenue Manasquan, NJ 08736
88245	WINCHESTER ELECTRONICS	Litton Systems-Useco Division 1536 Saticoy Street Van Nuys, CA 91409
90201	MALLORY CAPACITOR COMPANY	Sub of Emhart Industries, Inc. 4760 Kentucky Avenue P. O. Box 372 Indianapolis, IN 46206

CODE	MANUFACTURER	ADDRESS
91506	AUGAT, INC.	33 Perry Avenue P. O. Box 779 Attleboro, MA 02703
91637	DALE ELECTRONICS, INC.	2064 12th Avenue P.O. Box 609 Columbus, NE 68601 PHONE: 402-563-6301
91836	KINGS ELECTRONICS COMPANY, INC	40 Marbledale Road Tuckahoe, NY 10707 PHONE: 914-793-5000
92194	ALPHA WIRE CORPORATION	71 Lidgerwood Avenue Elizabeth, NJ 07207 PHONE: 201-925-8000
95146	ALCO ELECTRONIC PRODUCTS, INC.	1551 Osgood Street North Andover, MA 01845
95238	CONTINENTAL CONNECTOR CORPORATION	34-63 56th Street Woodside, NY 11377 PHONE: 212-899-4422
95987	WECKESSER COMPANY, INC.	Chicago, IL
98291	SEALECTRO CORPORATION	225 Hoyt Mamaroneck, NY 10544
99800	AMERICAN PRECISION INDUSTRIES, INC.	Delevan Division 270 Quaker Road East Aurora, NY 14052 PHONE: 716-652-3600

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